Comparison of ground beetles (Coleoptera: Carabidae) and spiders (Araneae) collected in pan and pitfall traps

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Pitfall trapping is a widely used sampling method for biodiversity-related research of ground-dwelling arthropods. The trap is a container, usually with a preservative, that is sunk into the ground to collect arthropods which happen upon the trap perimeter and fall in (Lemieux and Lindgren 1999; Work *et al.* 2002). Two types receive the most use: deep circular pitfall traps and shallow rectangular pan traps (Marshall *et al.* 2001). The preserving fluid can influence trap efficacy (Deville and Wheeler 1998). Our objectives were to compare the efficiency of pitfall and pan traps with and without detergent in the preserving fluid (Marshall *et al.* 1994), using carabid beetles (Coleoptera: Carabidae) and spiders (Araneae) as focal taxa.

Sampling was conducted at the George Lake Field Station (53°57′N, 114°06′W), near Edmonton, Alberta, Canada, where the forest is >100 years old and is dominated by *Populus tremuloides* Michx. (Spence and Niemelä 1994). Pan traps were rectangular white plastic trays measuring 14.2 × 10.2 × 3.5 cm with a 48.6-cm perimeter. Pitfall traps were nested white plastic cups; the inner sampling cup measured 11 cm in diameter and 6 cm deep, with a 34.5-cm perimeter (Spence and Niemelä 1994). Traps were installed so that the trap lip was flush with the substrate. Both traps had a square plywood roof measuring 15 × 15 cm that was held 2–3 cm above the traps with nails in each corner. Silicate-free ethylene glycol was used as a preservative, to a depth of approximately 2 cm. In half of the traps, 3–4 drops (approximately 0.75 mL) of detergent (No-Name™ brand, lemon-scented) was added. Sixteen pitfall and 16 pan traps were distributed on 5 June 1997 and removed on 14 August 1997, in a grid, with 15 m between traps. A two-factor design was used with two levels of each factor: pitfall or pan trap, with or without detergent. Treatments were assigned randomly. New preservative and detergent was added approximately every 2 weeks when samples were collected. Ground beetles and spiders were identified following Platnick (2003) and Bousquet (1991). Immature spiders were excluded because accurate determinations could not be made. Voucher specimens are in the Strickland Entomological Museum (University of Alberta, Edmonton) and Northern Forestry Centre, Edmonton, Alberta.

Catches from pan traps were multiplied by 0.71 to adjust for the different perimeters of the two traps (Work *et al.* 2002). Seven pan and 9 pitfall trap samples were lost out of the 160 samples (32 traps by 5 collection dates), because of disturbance by vertebrates or flooding. Individual trap counts were standardized to the number collected per 61.6 trapping-days, the average number of trapping-days per trap on an experiment-wide basis, and treatment totals were standardized to 492.5 trapping-days. Species diversity was estimated using rarefaction estimates of the expected number of species

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TABLE 1. Number, species richness, and species diversity of carabid beetles and spiders collected by pitfall and pan traps with or without detergent added to the preservative.

	Pitfall trap		Pan trap	
	Control	Detergent	Control	Detergent
Carabid beetles				
Standardized number collected	360.5	358.4	626.6	419.9
Number (mean ± SE) collected per trap (n = 8)	44.7±9.18	45.2±9.78	78.4±18.73	51.8±6.28
Species richness	17	17	19	19
Expected number of species (mean ± SD)	16.9±0.24	16.7±0.54	15.4±1.30	16.2±1.34
Spiders				
Standardized number collected	244.2	203.5	145.6	147.2
Number (mean ± SE) collected per trap (n = 8)	33.6±9.92	28.7±10.55	18.7±3.52	18.7±2.98
Species richness	32	27	23	24
Expected number of species (mean ± SD)	29.5±1.39	25.7±1.03	21.8±0.99	23.7±0.49

NOTE: Expected number of species is based on rarefaction analyses at a subsample size of 340 carabid beetles and 190 spiders.

using a subsample size (number of specimens) (Simberloff 1978). Transformations were not required and nonsignificant interaction terms (*i.e.*, trap type × solution) were removed prior to the final analysis in a two-factor ANOVA on the relative abundance (standardized catch) of each taxa, species richness, and relative abundance (standardized catch) of the most commonly collected species defined as those representing ≥5% of the entire sample.

A total of 2204 carabid beetles in 27 species and 858 spiders in 43 species (plus 3 undetermined species) were collected (Buddle and Hammond 2003). More beetles tended to collect in pan than in pitfall traps, whereas more spiders tended to collect in pitfall than in pan traps (Table 1); however, these differences were not significant (trap type: ground beetles: $F_{1,28} = 2.82$, $P = 0.104$; spiders: $F_{1,28} = 2.76$, $P = 0.107$). Estimates of carabid species richness did not differ by either trap type ($P = 0.145$) or solution type ($P = 0.285$) (Table 1). Pitfall traps without detergent had a more diverse spider fauna than other trap types, based on rarefaction estimates (Table 1), and supported the highest number of unique species (10). Spider species richness was higher in pitfall than in pan traps ($F_{1,28} = 7.89$, $P = 0.009$).

Species-specific responses to trap type were detected for only three of the carabids. The interaction term for *Pterostichus pensylvanicus* LeConte (Coleoptera: Carabidae) ($F_{1,28} = 5.89$, $P = 0.023$) was due to a fourfold increase in abundance in pan traps that did not contain detergent compared with other treatments. *Calathus ingratus* Dejean (Coleoptera: Carabidae) was less common in traps containing detergent [relative abundance (mean ± SE) with detergent was 9.2 ± 1.37 and without detergent was 19.4 ± 3.80; $F_{1,28} = 6.26$, $P = 0.018$]. *Platynus decentis* (Say) (Coleoptera: Carabidae) showed the opposite response to solution type (relative abundance with detergent was 13.6 ± 2.63 and without detergent was 7.9 ± 1.95; $F_{1,28} = 3.19$, $P = 0.084$).

In central Alberta, pan traps caught 1.5 times more carabid beetles than pitfall traps and pitfall traps caught approximately 1.7 times more spiders than pan traps, although these differences were not statistically significant. Measures of species richness and diversity of ground beetles were largely insensitive to trap type or detergent in the preservative. Spider species richness and diversity were highest in pitfall traps without detergent, and pitfall traps collected more species than pan traps. Adding detergent to the preservative solution had little effect on the spider assemblage but reduced the catch of *C. ingratus* and increased that of *P. decentis*. Because processing time and trap servicing

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are similar for pan and pitfall traps, the choice of trap type should be based on the need to determine quantitative differences in arthropod collections in relation to the study objectives. In some cases, pan traps may be most suitable if ground beetles are to be collected in large numbers, but in general, pitfall traps without detergent are the most suitable because this trap type maximizes collections of spiders without greatly reducing the number of ground beetle species collected.

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